Tennessee Valley Authority, Post Office Box 2000, Soddy Daisy, Tennessee 37384-2000

September 22, 2015

10 CFR 50.73

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Unit 1
Facility Operating License No. DPR-77
NRC Docket No. 50-327

Subject: **Licensee Event Report 50-327/2015-002-00, "Automatic Reactor Trips due to Improper Wire Termination in Main Generator Voltage Regulator Circuit"**

The enclosed Licensee Event Report provides details concerning two automatic reactor trips each following a turbine trip. These events were due to an improper wire termination in the main generator voltage regulator circuit. This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(iv)(A), as events that resulted in a manual or automatic actuation of the Reactor Protection System and the Auxiliary Feedwater System. This condition had no impact on Unit 2.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this submittal, please contact Mr. Jon Johnson, Acting Sequoyah Site Licensing Manager, at (423) 843-8129.

Respectfully,

John T. Carlin
Site Vice President
Sequoyah Nuclear Plant

Enclosure: Licensee Event Report 50-327/2015-002
cc: NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant

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NRC FORM 366 (02-2014) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 01/31/2017

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA, Privacy and Information Collections Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See Page 2 for required number of digits/characters for each block)

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4. TITLE

Automatic Reactor Trips due to Improper Wire Termination in Main Generator Voltage Regulator Circuit

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
07	24	2015	2015	- 002	- 00	09	22	2015	NA	
									FACILITY NAME	DOCKET NUMBER
									NA	

9. OPERATING MODE	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*			
1	☐ 20.2201(b)	☐ 20.2203(a)(3)(l)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vil)
	☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
	☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
	☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
10. POWER LEVEL	☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
	☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
100	☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
	☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
	☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

LICENSEE CONTACT	TELEPHONE NUMBER *(Include Area Code)*
Rebecca L. Travis	423-843-8335

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
D	EL	RG	W120	Y					

14. SUPPLEMENTAL REPORT EXPECTED	15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO				

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On July 24, 2015, at 1351 Eastern Daylight Time (EDT), Sequoyah Nuclear Plant (SQN) Unit 1 reactor automatically tripped following a turbine trip due to actuation of the generator backup relay. The relay actuation was a result of voltage variations on the main generator. A malfunctioning base adjuster follower card was identified on the main generator voltage regulator. After replacement of the base adjuster circuit card, Unit 1 was connected to the grid and ascending in power. On July 27, 2015, at 1040 EDT SQN Unit 1 reactor was at 82 percent power when it automatically tripped following a turbine trip due to actuation of the generator backup relay. An improperly terminated wire was found in the voltage regulator logic drawer which caused high resistance. Prior to restart, the wire was properly connected. Following each of the reactor trips, all safety related equipment operated as designed, all control rods fully inserted as required, and auxiliary feedwater automatically initiated from the feedwater isolation signal as expected. The cause of each of the reactor trips was determined to be inadequate standards for multi-wire terminations and verification at the time of the original improper wire termination event in the mid-1990s. Corrective actions to prevent recurrence include adding guidance for multi-wire terminations to Modifications and Additions Instruction M&AI-7.1, Cable Terminations and Repairing Damaged Cables. The condition described in this LER did not have an impact on SQN Unit 2.

NARRATIVE

I. PLANT OPERATING CONDITIONS BEFORE THE EVENT

At the time of the first event, Sequoyah Nuclear Plant (SQN) Unit 1 and Unit 2 reactors were operating at approximately 100 percent rated thermal power (RTP). At the time of the second event, SQN Unit 1 reactor was operating at 82 percent RTP and SQN Unit 2 reactor was operating at approximately 100 percent RTP. The events described in this LER did not have an impact on SQN Unit 2.

II. DESCRIPTION OF EVENTS

A. Event:

On July 24, 2015, at 1351 Eastern Daylight Time (EDT), SQN Unit 1 reactor automatically tripped following a turbine trip due to actuation of the 186GBX Generator Backup Relay [EIIS Code 86]. Prior to the turbine trip, the unit had been experiencing erratic oscillations on Generator voltage, volt-ampere reactive power (VARs), and exciter voltage and amperage. These erratic oscillations were later determined to be unrelated to the reactor trip. Two attempts were made by the plant operator to control the Voltage Regulator [EIIS Code RG] in an attempt to stabilize voltage. The unit tripped following the second attempt to control the oscillations when voltage control was switched to manual. Maintenance troubleshooting identified problems with the voltage regulator base adjustor follower card. This card was replaced and plant start-up commenced.

On July 27, 2015, at 1040 EDT, while operating at 82 percent RTP during power ascension, SQN Unit 1 reactor automatically tripped following a turbine trip due to actuation of the 186GBX Generator Backup Relay. Prior to the turbine trip, the plant had been experiencing mega-volt-ampere reactive power (MVAR) spikes lasting about 30 seconds each with an amplitude of about 40 MVAR. These spikes were different from the erratic oscillations leading up to the July 24, 2015, reactor trip. These spikes were all positive MVARs of similar magnitude and duration rather than random oscillations that were both positive and negative. During maintenance activities, a wire that connects the power supply common terminal to the Protective Drawer through the logic drawer from the Firing Circuit Drawers was found to be improperly terminated. After it was properly connected, plant start-up commenced.

For both events, all safety related equipment operated as designed, all control rods fully inserted as required, and auxiliary feedwater automatically initiated from the feedwater isolation signal as expected. No complications were experienced during the reactor trips.

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B. Status of structures, components, or systems that were inoperable at the start of the event and contributed to the event:

There were no structures, components, or systems that were inoperable at the start of the event.

C. Dates and approximate times of occurrences:

On July 24, 2015 at 1340 EDT, generator voltage, VARs, exciter voltage and amperage, and voltage regulator null meter were swinging erratically. The voltage regulator was momentarily placed in manual and the swings could not be dampened. The voltage regulator was placed back in automatic control. The fluctuations continued to worsen and exciter voltage dropped. The voltage regulator was again placed in manual control and the exciter voltage base adjuster hand switch was placed in the raise position with no response. At 1351, the Unit 1 reactor automatically tripped with first out indications of "Electrical Trouble" and "Turbine Trip". During maintenance activities, vendor as found testing discovered unexpected values for the base adjuster follower card. The base adjuster follower card was then replaced.

On July 27, 2015 at 0036 EDT, the Unit 1 generator was synchronized to the grid. Following synchronization, random MVAR spikes start occurring. The first spike occurred as the generator was synced to the grid and occurred at a greater frequency during ascent in reactor power. In order to dampen the MVAR spikes experienced on the Unit 1 turbine voltage regulator, operators placed the voltage regulator in manual. Severe swings on MVARs were experienced and manual adjustments were not adequate to bring the load under control. On July 27, 2015 at 1040 EDT, the Unit 1 reactor automatically tripped, following a turbine trip. During maintenance activities, an improperly terminated wire was found in the regulator logic drawer. The wire was properly re-terminated and no other issues were found. On July 30, 2015 at 2337 EDT, the Unit 1 generator was synchronized to the grid.

Date/Time	Description
July 24, 2015 at 1340 EDT	Generator voltage, VARs, exciter voltage and amps, and voltage regulator null meter were swinging erratically.
July 24, 2015 at 1351 EDT	The Unit 1 reactor automatically tripped.

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July 25, 2015 at 1200 EDT	The base adjuster follower card was replaced following discovery of unexpected values.
July 27, 2015 at 0036 EDT	Unit 1 generator synchronized to the grid.
July 27, 2015 at 0036 -1040 EDT	Random MVAR spikes started occurring and increased during ascent in reactor power.
July 27, 2015 at 1040 EDT	Operators placed the automatic voltage regulator in manual. This was followed by severe swings of MVARs. The Unit 1 reactor automatically tripped.
July 28, 2015 at 0000 EDT	An improperly terminated wire was found in the regulator logic drawer and was properly re-terminated.
July 30, 2015 at 2337 EDT	Unit 1 generator synchronized to the grid.

D. Manufacturer and model number of each component that failed during the event:

The failed component was a Westinghouse/Siemens WTA single channel analog type automatic voltage regulator.

E. Other systems or secondary functions affected:

There were no other systems or functions affected by this event.

F. Method of discovery of each component or system failure or procedural error:

After Unit 1 automatically tripped on July 24, 2015, maintenance troubleshooting was performed on the voltage regulator with a simulated load. At this time, it was believed that the cause of the Unit 1 power oscillations, loss of excitation, and subsequent trip was erratic movement of the base adjuster caused by a malfunctioning base adjuster follower card.

After Unit 1 automatically tripped on July 27, 2015, maintenance troubleshooting efforts identified that the single wire that connects the power supply common to the Protective Drawer through the logic drawer from the Firing Circuit Drawers had a high ohmic resistance. Investigation of the high resistance connection resulted in finding a ring lug was not captured by the terminal screw and was held in place by a combination of compression/friction with other lugs and wire ties from its wire bundle. After removing some of the wire bundle ties, this improperly terminated wire sprang from the bundle,

dislocating and electrically disconnecting itself from the other two common wires. This wire was concluded to be the source of the high resistance connection.

G. The failure mode, mechanism, and effect of each failed component, if known:

The malfunctioning base adjusted follower card was determined not to be the cause of the unit trips. The improperly terminated wire in the voltage regulator logic drawer resulted in an inaccurate automatic voltage regulator/manual base adjuster balance meter indication in the Main Control Room and the base adjustor having a built in high negative output. When the regulator was transferred from auto to manual, operators were unaware that a high deviation between the auto function and the manual base regulator output was present. When these transfers were made on July 24 and 27, 2015, excitation rapidly decreased, resulting in a negative MVAR swing. Subsequently, this swing actuated generator protective relays, tripping the unit both times.

H. Operator actions:

The operators entered Emergency Procedure E-0, Reactor Trip or Safety Injection and then transitioned from E-0 to Emergency Subprocedure ES-0.1, Reactor Trip Response.

I. Automatic and manually initiated safety system responses:

Following the reactor trips, all plant safety systems responded as designed. All control rods fully inserted as required. Auxiliary feedwater automatically initiated from the feedwater isolation signal as expected.

III. CAUSE OF THE EVENT

A. The cause of each component or system failure or personnel error, if known:

The direct cause of each of the trips was determined to be an improperly terminated wire for the Protective Drawer and Main Control Room null meter common power circuit.

B. The cause(s) and circumstances of each human performance related root cause:

The root cause was determined to be inadequate standards for multi-wire terminations and verification at the time of the improper wire termination event. It is believed that the original error occurred sometime prior to the mid-1990s, when the wire termination documentation for exciter work orders of the maintenance electric group shifted to more formal independent verification. The root cause analysis is documented in Condition Report (CR) 1062507.

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IV. ANALYSIS OF THE EVENT

SQN Unit 1 automatically tripped following a turbine trip due to actuation of the 186GBX Generator Backup Relay on July 24, 2015 and July 27, 2015. The relay actuations were a result of negative MVAR swings caused by an improperly terminated wire for the Protective Drawer and MCR null meter common power circuit. In each of the reactor trips, all auxiliary feedwater (AFW) pumps, steam dump valves, and atmospheric relief valves were available. Each plant transient response including reactor power, reactor coolant system (RCS) pressure, RCS temperature, pressurizer level, RCS secondary side pressure, and AFW flow remained within technical specification limits and were bounded by the Final Safety Analysis Report (FSAR) section 15.2.7, Loss of External Electrical Load And/Or Turbine Trip accident analysis. Containment pressure, temperature, and radiation were unaffected by these transients. Steam generator level experienced during these events was bounded by FSAR analysis. The plant responded as expected for the conditions of the trips.

Troubleshooting efforts led to discovery of two abnormalities in the voltage regulator cabinets. The dead band of the base adjuster follower had drifted out of calibration. In addition, a wire running between the Protection Drawer and logic drawer was found to be incorrectly terminated at a junction point. The improperly terminated wire resulted in the main generator voltage regulator failing to perform its intended function and properly controlling generator excitation. As a result, the generator tripped when the voltage regulator was taken to manual control.

V. ASSESSMENT OF SAFETY CONSEQUENCES

There were no safety consequences as a result of the event. All safety systems functioned as designed and no complications were experienced.

A. Availability of systems or components that could have performed the same function as the components and systems that failed during the event.

There were no other components that could have performed the same function as the main generator voltage regulator.

B. For events that occurred when the reactor was shut down, availability of systems or components needed to shutdown the reactor and maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident.

These events did not occur when the reactor was shut down. Safety-related systems that were needed to shut down the reactor, maintain safe shutdown conditions, remove residual heat or mitigate the consequences of an accident remained available throughout the event.

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C. For failure that rendered a train of safety system inoperable, an estimate of the elapsed time from the discovery of the failure until the train was returned to service.

There was no failure that rendered a train of a safety system inoperable.

VI. CORRECTIVE ACTIONS

Corrective Actions are being managed by TVA's Corrective Action Program under CR 1062507.

A. Immediate Corrective Actions:

- Properly terminated loose wire.
- Added summary of this event to the Maximo preventive maintenance (PM) procedures for Unit 1 and Unit 2 exciters

B. Corrective Actions to Prevent Recurrence or to reduce the probability of similar events occurring in the future.

- Add guidance for multi-wire terminations to Modifications and Additions Instruction M&AI-7.1, Cable Terminations and Repairing Damaged Cables.

VII. ADDITIONAL INFORMATION

A. Previous similar events at the same plant.

A review of previous reportable events for the past 3 years identified six events caused by inadequate procedures. LER 2-2012-001 involved an automatic reactor trip on loss of flow due to a reactor coolant pump trip. The root cause was determined to be a lack of guidance in the PM instructions for replacement of the ground fault relay that caused the trip, which had reached the end of its service life. LER 1-2013-004-01 involved a failure to comply with TSs for containment penetrations during fuel movement resulting from ineffective procedures. LER 1-2014-001-00 involved a never performed TS surveillance for the Common Spare Component Cooling System (CCS) Pump due to lack of procedural guidance. LER 1-2014-002-00 involved inadequate revision to a surveillance instruction following a Technical Specification change. LER 2-2014-002-00 involved procedures not specifying an accurate drawing for reassembling the containment vacuum relief valve and also an inadequate operating instruction for reestablishing containment integrity. LER 2-2015-001 involved an automatic reactor trip due to the failure of the main generator C-phase neutral current transformer cable. The root cause was determined to be a lack of inspections in the PM procedure to identify potential failure mechanisms.

B. Additional information.

None.

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C. Safety System Functional Failure Consideration.

This event did not result in a safety system functional failure in accordance with 10 CFR 50.73(a)(2)(v).

D. Scrams with Complications Considerations.

This condition did not result in an unplanned scram with complications.

VIII. COMMITMENTS

None